An economic analysis of software piracy in a competitive cloud computing market: A product bundling perspective

Zhiyuan Liu
Beijing Jiao Tong University, 19711092@bjtu.edu.cn

Yuexiang Yu
Beijing Jiao Tong University, 19711113@bjtu.edu.cn

Jikun Lv
Beijing Jiao Tong University, 19711022@bjtu.edu.cn

Xiong Zhang
Beijing Jiao Tong University, xiongzhang@bjtu.edu.cn

Liu, Z.,Yu, Y., Lv, J. & Zhang, X. (2022). An economic analysis of software piracy in a competitive cloud computing market: A product bundling perspective. In Li, E.Y. *et al.* (Eds.) *Proceedings of The International Conference on Electronic Business, Volume 22* (pp. 35-44). ICEB'22, Bangkok, Thailand, October 13-17, 2022

An economic analysis of software piracy in a competitive cloud computing market: A product bundling perspective

Zhiyuan Liu [1]
Yuexiang Yu [2]
Jikun Lv [3]
Xiong Zhang [4,*]

*Corresponding author
[1] Undergraduate student, Beijing Jiao Tong University, Beijing, 19711092@bjtu.edu.cn
[2] Undergraduate student, Beijing Jiao Tong University, Beijing, 19711113@bjtu.edu.cn
[3] Undergraduate student, Beijing Jiao Tong University, Beijing, 19711022@bjtu.edu.cn
[3] Associate professor, Beijing Jiao Tong University, Beijing, China, xiongzhang@bjtu.edu.cn

ABSTRACT

In the cloud computing era, incumbent vendors are offering both on-premises software and cloud-based software service. Simultaneously, they are facing competition from new entries who just offer cloud-based software. However, piracy exists in on-premises software for incumbent vendors. Therefore, incumbent vendors are facing pressure from piracy and new entries at the same time. Using the framework of product bundling, this study builds a stylized analytical model to investigate the optimal product bundling strategies for software vendors in the presence of software piracy. The research found that the pure bundling strategy is the best choice for existing software vendors in the market in most cases because of the more flexible bundling price. Pure component strategy can be more profitable than pure bundling strategy when piracy costs are at the medium level.

Keywords: Software piracy, cloud computing, product bundling, market competition.

INTRODUCTION

Piracy has always been a significant obstacle to the software industry's healthy development (BSA, 2018). As Internet technology has developed, it has facilitated the transmission of information, but also exacerbated software piracy. Piracy severely infringes on developers' intellectual property, reduces the living space of licensed software, and has a negative impact on the development of future technologies. Product price is usually considered the main reason for users to choose software piracy. Therefore, vendors should fight against piracy by adopting appropriate pricing strategies.

Cloud computing is being considered another way to combat software piracy. By applying cloud computing technology, software vendors can not only regulate authentication and monitor customer usage but also limit access to reduce piracy (Wang, 2017). As a result, cloud computing has progressively become the primary focus of software vendors' development efforts. However, transferring traditional software vendors to cloud service is a lengthy and hazardous process. While traditional software vendors pay a higher setup fee than cloud software vendors, they charge on a demand or usage basis (Intellias, 2021). Due to the scale effect, traditional software vendors will not be able to easily abandon traditional software sales. At the same time, new cloud software competitors are entering the market. They usually only offer cloud computing services.

Simultaneously facing pressures of piracy in on-premises software channels and pressures of competition from new entries, incumbent vendors need to make decisions on whether to sell on-premises software and cloud-based software service individually, which is the Pure Component (PC) strategy or sell them together in a package, which is Pure Bundling (PB) strategy (Riordan et al., 2012). By building a stylized analytical model, this research uses a numerical method to investigate the optimal bundling strategies for software vendors under various market conditions.

In most circumstances, it is discovered that the PB outperforms the PC. The profit under PC may excess PB when Vendor I set a proper restriction on piracy. This article examines the ideal software bundling method in competitive markets, taking cloud computing functions and piracy into account. The scenario examined in this study is more representative of the current state of the software market and gives practical sales methods for software vendors in an era of coexistence of traditional and cloud computing software.

LITERATURE REVIEWS

Product Bundling

Product bundling has been widely examined in information systems and other fields. (Derdenger & Kumar, 2013) had investigated the bundling strategy of software and hardware. Bakos and Brynjolfsson (1999)) studied the bundling of information, commodities and pointed out that the bundling strategy of information commodities was different from that of traditional commodities because the marginal replication cost of information commodities was almost zero. Venkatesh and Kamakura found that marginal cost and complementarity among products would influence the optimal bundling strategy (Venkatesh & Kamakura, 2003). Pang and Etzion (2012)) studied the bundling of products and online software components. Gopal and Gupta (2010)) showed that manufacturers use bundling to combat the sharing clubs, and point out that product bundling can always add up to consumer surplus. In the recent research, researchers focus on the effect when adopting bundling strategy in different aspects. Honhon and Pan (2017)) analyze a firm that sells vertically differentiated components and the impact of adopting different bundling strategies. Shivendu and Zhang (2019)) focused on the analysis of a publisher who offers information goods in physical and digital mediums and also these two goods in a bundle. Some researchers studied the problem of software bundling in the era of cloud computing and considered the effect of piracy (Zhang & Yue, 2020; Zhang et al., 2019a, 2020). Dey et al. (2021)) focused on the free support forums effect on the software vendor and the software vendor's pricing strategy. Following the literature, this paper studies the problem of software bundling in the era of cloud computing. At the same time, this study introduces the competition between vendors of cloud computing and on-premises software, and more importantly, considers the impact of software piracy.

Software Piracy

Kim et al. (2018)) found that a moderate level of piracy has a positive impact on the profits of the manufacturer and a high surplus for consumers. Kim et al. (2022)) showed that high quality of the illegal copy associated with low quality development costs, which means it is optimal to eliminate piracy when the quality development cost is high. Zhang et al. (2021)) found that the intensity of market competition plays a critical role in the decisions on anti-counterfeit efforts. When market competition is less intense, there is a greater economic incentive to combat counterfeit selling. Some studies found that piracy may be used to prevent the entry of the entrants and found that accommodating piracy will be a better choice for some software vendors to maximize profits. Piracy acts instead as a deterrent to entrants (Nie et al., 2022). Some studies also found that the existence of software piracy also leads to a greater surplus for the users (Zhang et al., 2018). Some studies have explored the relationship between software quality and software piracy and found that the existence of pirated software to a certain extent will also encourage software suppliers to provide higher quality software (Lahiri & Dey, 2013). Zhang and Yue (2013)) focus on fighting against software piracy, they found that the bundling of software applications could be a way to minimize the negative impact of software piracy. Machado et al. (2017)) showed that firms may make more effort to control piracy when network externalities are strong. The sellers will try to maintain a large perceived quality gap between the product and piracy product.

Distinction From Existing Literature

Our study analyzes software piracy in the era of cloud computing. Especially in the case of market competition, from the Angle of commodity bundling analysis.

MODEL

Our study considers the market competition between two profit-maximizing vendors. Vendor I provides a software as a product and a software as a service (Products 1 and Product 2). Vendor I could choose one of the following two selling strategies: (1) sells products separately, which is a pure component, or PC, (2) sells both products in a software bundle, which is pure bundling, or PB. Vendor E provides only cloud-based software services (Product E) that offer similar functionality as Product 2 from Vendor I.

The consumer is heterogeneous. For Product 1 and Product 2, we regard r_1, r_2 as respective reserving utilities which follow a uniformly joint probability density distribution normalized to the range of 0 and 1, i.e., $(r_1, r_2) \in [0,1] \times [0,1]$. For Product E, between r_e and r_2, there is a proportion β, we assume that $r_e = \beta r_2$, with $\beta \in [0,1]$ to ensure the quality of Product E is inferior to that of Product 2.

Software products and cloud services may complement or substitute each other. We use α to denote the complementarity between software product and service. The utility of simultaneously using both software product and service would be $r_{12} = (1+\alpha)(r_1 + r_2)$, with $0 \leq \alpha < 1$. When purchasing product 1 and product 2 at the same time, consumers obtain not only the individual utility of the two products, but also the additional utility through the complementary effect. It is worth mentioning that since pirated software and Product E cannot coordinate online and offline through a unified account, it is assumed that the complementary level exists only between Product 1 and Product 2.

Vendor I sets prices of p_1 (p_2 or p_b) for Product 1(Product 2 or bundle). Vendor E sets the price of p_e for Product E. On the other hand, Vendor I and Vendor E incur fixed costs c and βc for each service user, such as computing, storage, runtime management, etc. Table 1 presents the selling options and associated utilities in each selling strategy.

Piracy exists in the software industry. Vendors often use DRM to manage piracy. When consumers choose to use pirated software, they need to face a particular piracy cost t. This cost can be understood as the searching cost, the fee paid for pirated software, or the possible fine or loss once discovered. In addition, we assume that the piracy cost is the same under PC and PB.

Table 1: Purchase Options and Utility

Strategy	Options	Purchase Options	Utility
PC	o_1	None	0
	o_2	Product 2	$r_2 - p_2$
	o_3	Product 1 and Product 2	$(1+\alpha)(r_1+r_2) - p_1 - p_2$
	o_4	Pirated Product 1	$r_1 - t$
	o_5	Pirated Product 1 and Product 2	$r_1 + r_2 - t - p_2$
	o_6	Product E	$r_e - p_e$
	o_7	Pirated Product 1 and Product E	$r_1 + r_e - t - p_e$
PB	o_1	None	0
	o_2	Bundle	$(1+\alpha)(r_1+r_2) - p_b$
	o_3	Pirated Product 1	$r_1 - t$
	o_4	Product E	$r_e - p_e$
	o_5	Pirated Product 1 and Product E	$r_1 + r_e - t - p_e$

When buying both Product 1 and Product 2, consumers can obtain the utility of $(1+\alpha)(r_1+r_2) - p_1 - p_2$ in PC or $(1+\alpha)(r_1+r_2) - p_b$ in PB. However, when a consumer buys Product 2 and uses pirated Product 1, the utility is $r_1 + r_2 - t - p_2$. When a consumer buys Product E and uses pirated Product 1, the utility is $r_1 + r_e - t - p_c$. Consumer evaluates the net utility from each purchase option to choose the option leading to the highest utility. For example, if the utility consumer got from piracy is higher than the utility got from purchasing Product 1, i.e., $r_1 - t > r_1 - p_1$, in other words, $t < p_1$, consumers will be inclined to pirate products.

Figure 1 shows market segmentation in PC and PB, with scenarios derived from specific parameter values, including price and piracy costs. In Figure 1, there are 7 consumer groups, each buying one purchase option in PC and PB (see Table 1).

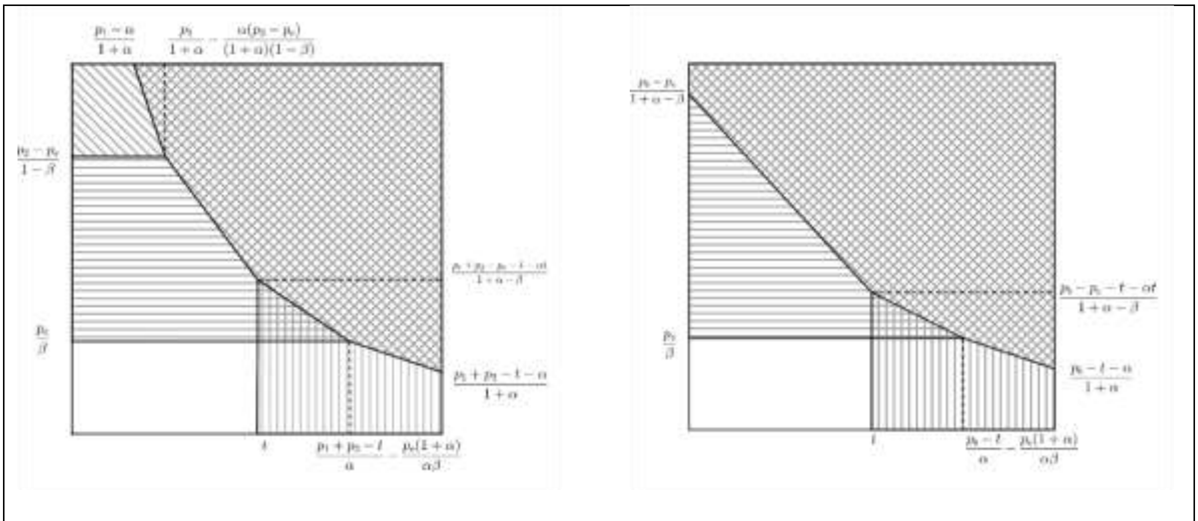


Figure 1: Market Segmentation of PC and PB

ANALYSIS

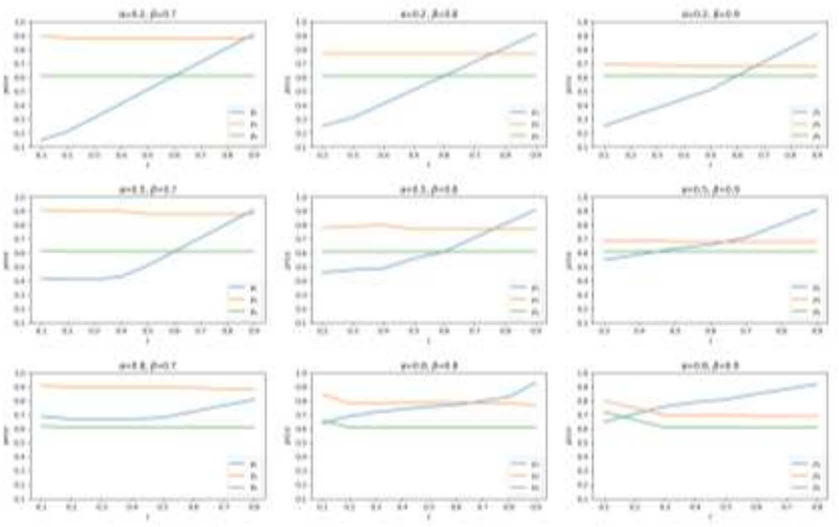
In product bundling in the presence of market competition, it is difficult to obtain analytical solutions. Numerical simulation methods will be used in this context. The research uses numerical analysis and set up several combinations of parameters. Research finally obtained the price strategies and the corresponding profit changes for Vendor E and Vendor I under PC and PB strategies respectively. The results are as follows:

Observation 1: *In PC,*

(1) When piracy cost t increases, p_2 and p_e remain stable and p_1 increases;

(2) As the service utility ratio β increases, p_2 and p_e remain stable and p_1 decreases;

(3) As the complementary level α increases, p_2 and p_e remain stable and p_1 increases.



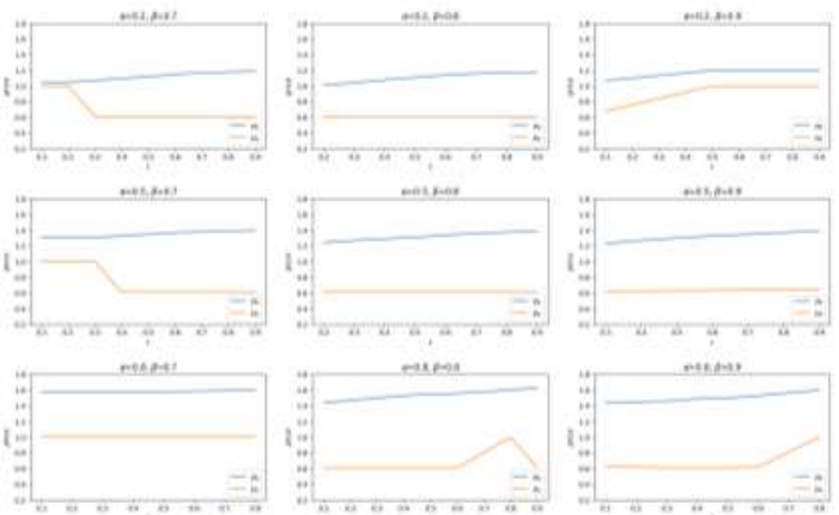
$\alpha \in \{0.2, 0.5, 0.8\}, \beta \in \{0.7, 0.8, 0.9\}, c = 0.6$

Figure 2: Price Comparison in PC

As t increases, consumers' utility from piracy decreases. Compared to pirated Product 1, consumers are more willing to buy licensed Product 1. As the demand for Product 1 increases, Vendor I is able to make higher profits from consumers by increasing prices, so p_1 tends to increase. p_2 and p_e prices remain stable because they are not affected by piracy. As β increases, Vendor E becomes more competitive and Vendor I chooses to lower price to maintain advantage and attract more consumers in the competition. This price reduction strategy results in Vendor I's utility always being higher than Vendor E. When α increases, consumers will get higher utility from purchasing bundling products. Therefore, Vendor I will choose to raise prices to obtain higher profits, p_1 increases with an increase in α.

When analyzing PB strategy, we find:

Observation 2: *In PB,*
(1) As the cost of piracy t *increases,* p_e *remains stable;*
(2) As the service utility ratio β *increases, both* p_e *and* p_b *remain stable;*
(3) As the complementary level α *increases,* p_e *remains stable and* p_b *has a small increase.*



$\alpha \in \{0.2, 0.5, 0.8\}, \beta \in \{0.7, 0.8, 0.9\}, c = 0.6$

Figure 3: Price Comparison in PB

When t increases, p_e remains stable because it is not affected by piracy. In Figure 3, p_b is always higher than p_e. When Vendor I chooses PB, it can always maintain a dominant position in the market and make higher profits. Because of Product E's lower utility, Vendor E can only earn a small profit from the market by pricing almost at cost. As α increases, bundling becomes more attractive to consumers, and consumers' demand for bundling products increases. Therefore, Vendor I chooses to raise prices to earn higher profits.

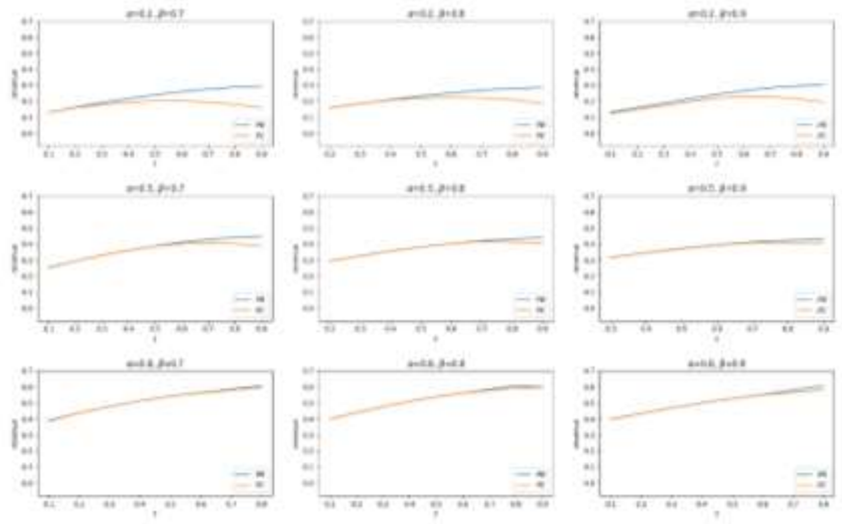
When analyzing profits under both strategies, we find:

Observation 3:

(1) As the cost of piracy t increases, profits under PB and PC increase;

(2) As the complementarity level α increases, the profits under PB and PC increase;

(3) As the utility ratio β increases, the profit under PB remains stable, and the profit under PC increases.



$\alpha \in \{0.2, 0.5, 0.8\}, \beta \in \{0.7, 0.8, 0.9\}, c = 0.6$

Figure 4: Revenue Comparison (PB vs PC)

As t increases, the profit of Vendor I under PB rises. This is because in PB, the only product combination of Vendor I is bundling, which is easier to maintain high user utility. However, PC products combination also includes services that are sold individually, which competes more fiercely with the newly added vendor E service. Compared to PB, vendor E service is able to gain more market share under PC. The increase of t also means that Vendor I pays more on DRM cost, thus increasing the price of Product 1. In more situations, the services become the choice with the highest utility for Vendor I. When Product E's utility exceeds services' utility, Vendor E will be more competitive. Thus, as t increases, the gap between PB and PC grows. As α increases, bundling under PC has the highest utility. For Product E, it's hard to have higher utility than bundling product. Therefore, Vendor I profits under PC increase and become closer to PB. The increased complementarity also increases the total profitability of Vendor I under both strategies. When β is increased, Product E's utility increases, but the cost increase either. With parameters shown in Table 4, there is a small increase in Vendor I profit under the PC strategy as beta increases.

Observation 4:

When t is in the middle, Vendor I may obtain higher profit under PC than under PB; Otherwise, Vendor I obtain higher profit under PB than under PC.

When t is in the middle, it's more profitable for Vendor I to choose PC. When t is large or small, it's more profitable for Vendor I to choose PB. When t is in the middle, piracy level is also in the middle. Vendor I choose PC strategy to sell software product and service separately to curb piracy. When t is small, the cost of piracy is low, piracy is more rampant. Vendor I choose PB strategy to sell software product and service as a bundle instead of selling them separately. When t is large, the cost of piracy is high, price of software product is also high. Vendor I choose PB.

CONCLUSION

This study focuses on the current landscape of software industry by paying attention to the software piracy problem in a competitive market. We investigate the optimal piracy curbing strategy in the cloud computing era using a product bundling framework. We use both analytical modeling and numerical simulation methods to observe the effects of complementarity, piracy costs, software service infrastructure costs, and other factors. We find that in most cases PB is the better strategy for the incumbent vendor because it could set a lower bundle price, thus users could get higher utility, and eventually attracts more users to buy. PC is better than PB only when the cost of piracy is in the middle range. Because more users tend to choose piracy product when the cost of piracy is low, and when the cost of piracy is high the cost of fighting piracy is high. These two reasons lead to a decrease in total profit.

ACKNOWLEDGMENT

This research is supported by grants from the National Natural Science Foundation of China (Grant 71801014) and Beijing Social Science Foundation (Grant 17GLC069). Xiong Zhang (xiongzhang@bjtu.edu.cn) is the corresponding author.

REFERENCES

Bakos, Y., and Brynjolfsson, E. 1999. "Bundling Information Goods: Pricing, Profits, and Efficiency," Bakos, Y., & Brynjolfsson, E. (1999). Bundling information goods: Pricing, profits, and efficiency. Management science, 45(12), 1613-1630.

BSA. (2018, March 28). 2018 Global Software Survey. https://gss.bsa.org/

Derdenger, T., & Kumar, V. (2013). The dynamic effects of bundling as a product strategy. Marketing Science, 32(6), 827-859.

Dey, D., Ghoshal, A., & Lahiri, A. (2021). Support Forums and Software Vendor's Pricing Strategy. Information Systems Research, 32(2), 653-669.

Gopal, R. D., & Gupta, A. (2010). Trading higher software piracy for higher profits: The case of phantom piracy. Management science, 56(11), 1946-1962.

Honhon, D., & Pan, X. A. (2017). Improving profits by bundling vertically differentiated products. Production and Operations Management, 26(8), 1481-1497.

Intellias. (2021, June 22). On-premise vs cloud: Pros and cons + cost comparison. https://intellias.com/cloud-computing-vs-on-premises-comparison-guide/

Kim, A., Lahiri, A., & Dey, D. (2018). The" Invisible Hand" of Piracy: An Economic Analysis of the Information-Goods Supply Chain. MIS Quarterly, 42(4).

Kim, B. C., Park, S. E., & Straub, D. W. (2022). Pay-What-You-Want Pricing in the Digital Product Marketplace: A Feasible Alternative to Piracy Prevention? Information Systems Research.

Lahiri, A., & Dey, D. (2013). Effects of piracy on quality of information goods. Management science, 59(1), 245-264.

Machado, F. S., Raghu, T., Sainam, P., & Sinha, R. (2017). Software piracy in the presence of open source alternatives. Journal of the Association for Information Systems, 18(1), 3.

Nie, J., Zhong, L., Li, G., & Cao, K. (2022). Piracy as an entry deterrence strategy in software market. European Journal of Operational Research, 298(2), 560-572.

Pang, M.-S., & Etzion, H. (2012). Research note—analyzing pricing strategies for online services with network effects. Information Systems Research, 23(4), 1364-1377.

Riordan, M., Gandal, N., & Markovich, S. (2012). AIN'T IT" SUITE"? BUNDLING IN THE PC OFFICE SOFTWARE MARKET. Strategic Management Journal, 39(8), 2120–2151. https://doi.org/10.1002/smj.2797

Shivendu, S., & Zhang, R. A. (2019). The impact of digitization on content markets: Prices, profit, and social welfare. Forthcoming, MIS Quarterly.

Venkatesh, R., & Kamakura, W. (2003). Optimal bundling and pricing under a monopoly: Contrasting complements and substitutes from independently valued products. The Journal of business, 76(2), 211-231.

Wang, S. (2017). The cloud, online piracy and global copyright governance. International Journal of Cultural Studies, 20(3), 270-286.

Zhang, X., & Yue, W. (2013, December 15-18). Bundling of software products and services to fight against piracy The Thirty-Fourth International Conference on Information Systems (ICIS2013), Milan, Italy.

Zhang, X., & Yue, W. T. (2020). Integration of on-premises and cloud-based software: the product bundling perspective. Forthcoming in Journal of the Association for Information Systems, 21(6).

Zhang, X., Yue, W. T., & Hui, W. (2018, Aug 24-26). Is Pirates' Loss Consumers' Gain? Software Piracy and Bundling Strategy The 24th Cross Strait Conference of Information Management Development and Strategy (CSIM2018), Hong Kong.

Zhang, X., Yue, W. T., & Hui, W. (2019a). Software piracy and bundling in the cloud-based software era. Information Technology & People.

Zhang, X., Yue, W. T., & Hui, W. (2019b). Software piracy and bundling in the cloud-based software era. Information Technology & People, 32(4), 1085-1122. https://doi.org/10.1108/ITP-05-2018-0210

Zhang, X., Yue, W. T., & Hui, W. (2020). Bundling cloud software to Fight Piracy: An Economic Analysis. Internet Research, 30(1), 191-241.

Zhang, X., Zhang, X., Luo, X., & Yue, W. T. (2021). The Impact of Revenue Models on Anti-Counterfeiting Measures for Online Intermediaries. Information Systems Frontiers, 1-24.

APPENDIX

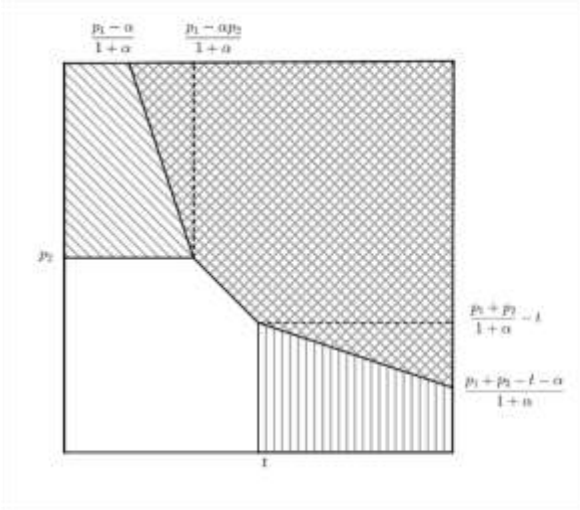
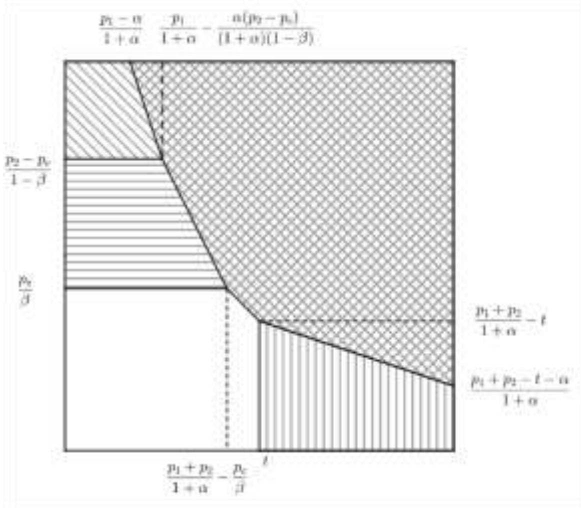
Before pure cloud service provider Vendor E enter the market, the whole market was dominated by the incumbent Vendor I. In this case, there are seven different cases for PC and three different cases for PB (Zhang et al., 2019b). Now when vendor E enters, several sub-cases would occur depending on the value of various parameters.

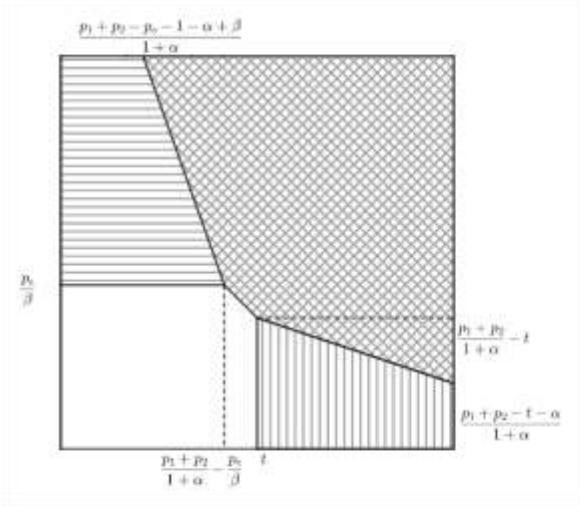
For PC, when $(p_1-\alpha)/(1+\alpha)>0$ *and* $(p_1+p_2-t-\alpha)/(1+\alpha)>0$ *,there are 7 sub-cases; When* $(p_1-\alpha)/(1+\alpha)<0$ *and* $(p_1+p_2-t-\alpha)/(1+\alpha)>0$*, there are 9 sub-cases; When* $p_2>(p_1-\alpha)/(1+\alpha)$ *and* $(p_1+p_2-t-\alpha)/(1+\alpha)>0$*, there are 4 sub- cases; When* $(p_1-\alpha)/(1+\alpha)>1$ *and* $(p_1+p_2-t-\alpha)/(1+\alpha)>0$*, there are 4 sub- cases; When* $(p_1-\alpha)/(1+\alpha)<0$ *and* $(p_1+p_2-t-\alpha)/(1+\alpha)<0$*, there are 4 sub- cases; When* $p_2>(p_1-\alpha)/(1+\alpha)$ *and* $(p_1+p_2-t-\alpha)/(1+\alpha)<0$*, there are 3 sub- cases; When* $(p_1-\alpha)/(1+\alpha)<0$ *and* $(p_1+p_2)/(1+\alpha)-t<0$*, there are 3 sub- cases;*

For PB, When $p_b/(1+\alpha)>1$*, there are 4 sub- cases; When* $p_b/(1+\alpha)<1$ *and* $(p_b-t-\alpha)/(1+\alpha)>0$*, there are 7 sub- cases; When* $p_b/(1+\alpha)<0$*, there are 5 sub- cases;*

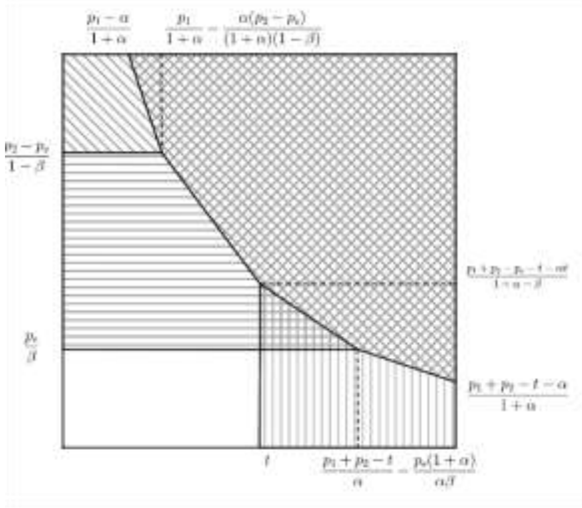
Due to page limitation, we only present two representative cases, PC when $(p_1-\alpha)/(1+\alpha)>0$ *and* $(p_1+p_2-t-\alpha)/(1+\alpha)>0$*, and PB when* $p_b/(1+\alpha)<1$ *and* $(p_b-t-\alpha)/(1+\alpha)>0$*. Analysis of other sub cases are available upon request.*

Table A1: Indifference curves for different models for PC

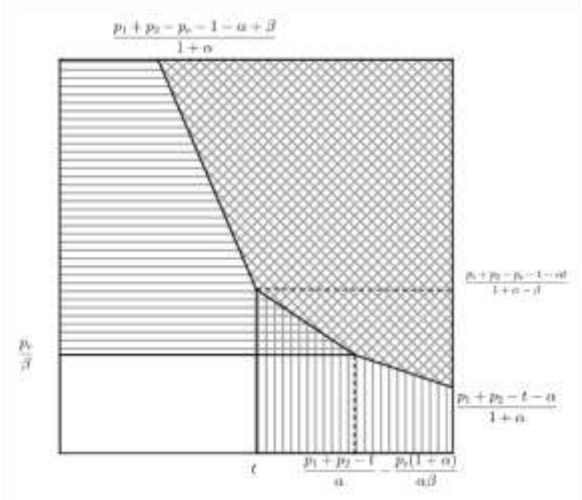
	
(a) $p_e/\beta>p_2$	**(b)** $p_2>p_e/\beta>(p_1+p_2)/(1+\alpha)-t$ *and* $(p_2-p_e)/(1-\beta)>1$



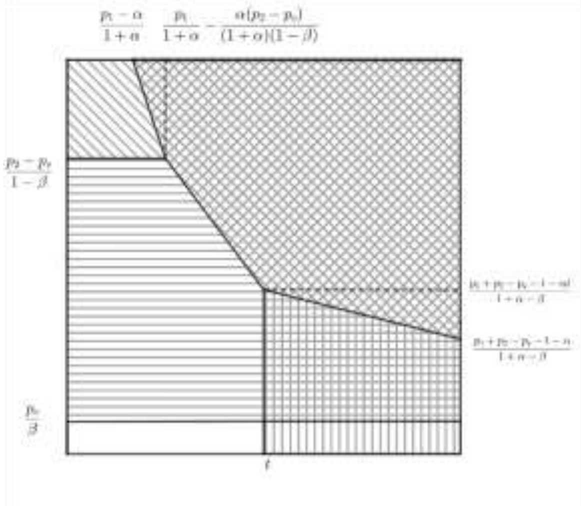
(c) $p_2 > p_e/\beta > (p_1+p_2)/(1+\alpha) - t$ *and* $(p_2 - p_e)/(1-\beta) < 1$;



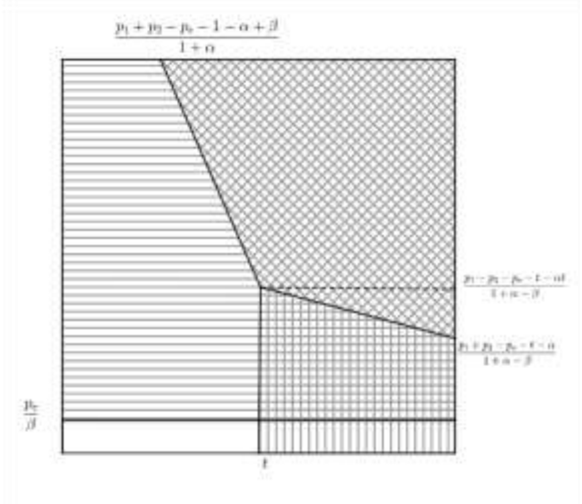
(d) $(p_1+p_2)/(1+\alpha) > p_e/\beta > (p_1+p_2-\alpha-t)/(1+\alpha)$ *and* $(p_2 - p_e)/(1-\beta) > 1$



(e) $(p_1+p_2)/(1+\alpha) > p_e/\beta > (p_1+p_2-\alpha-t)/(1+\alpha)$ *and* $(p_2 - p_e)/(1-\beta) < 1$



(f) $(p_1+p_2-\alpha-t)/(1+\alpha) > p_e/\beta > (p_1+p_2-\alpha-t)/(1+\alpha)$ *and* $(p_2 - p_e)/(1-\beta) > 1$



(g) $(p_1+p_2-\alpha-t)/(1+\alpha) > p_e/\beta > (p_1+p_2-\alpha-t)/(1+\alpha)$ *and* $(p_2 - p_e)/(1-\beta) < 1$

Legend:

Buy nothing Buy service product

Buy service product and software product

Buy piracy software product

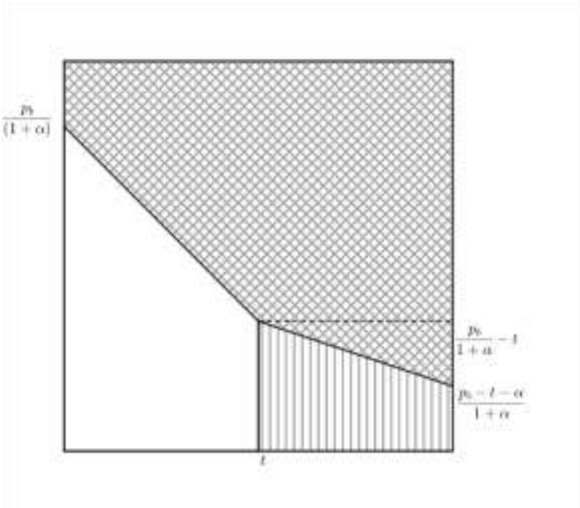
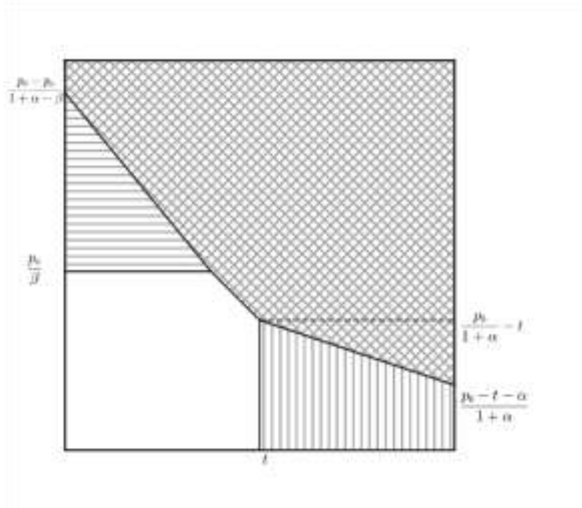
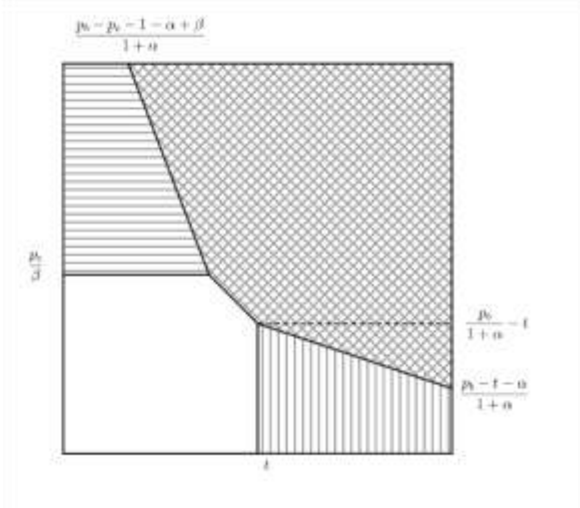
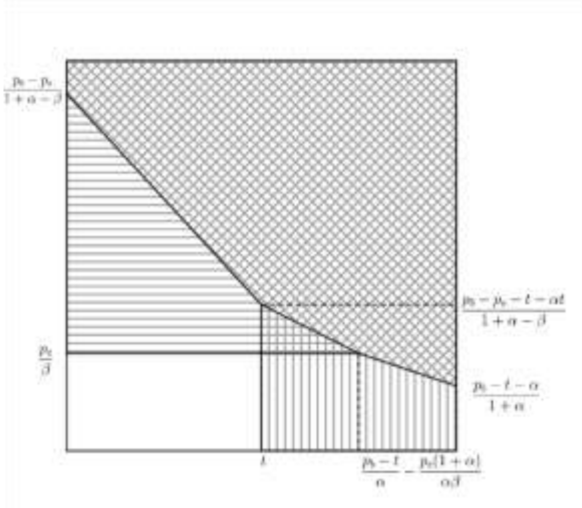
Buy vendor E's service product

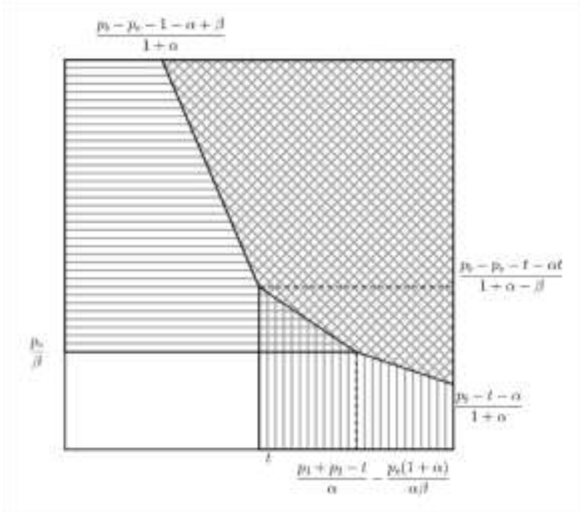
Buy vendor E's service product and piracy software product

Notes:

	$p_e/\beta > p_2$	$p_2 > p_e/\beta > (p_1+p_2)/(1+\alpha) - t$	$(p_1+p_2)/(1+\alpha) > p_e/\beta > (p_1+p_2-\alpha-t)/(1+\alpha)$	$(p_1+p_2-\alpha-t)/(1+\alpha) > p_e/\beta$
$(p_2-p_e)/(1-\beta) > 1$	**(a)**	**(b)**	**(d)**	**(f)**
$(p_2-p_e)/(1-\beta) < 1$		**(c)**	**(e)**	**(g)**

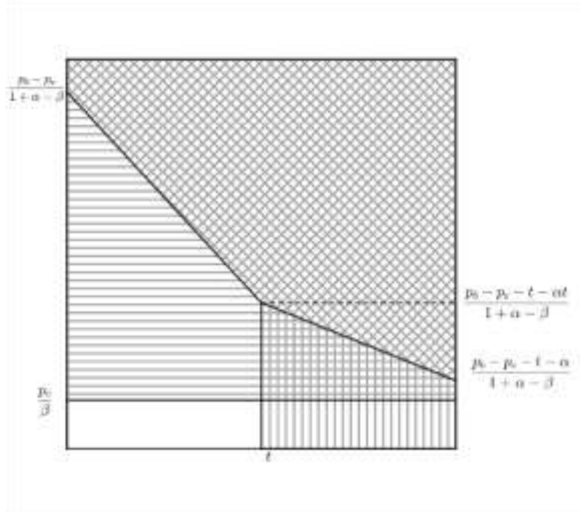
Table A2: Indifference curves for different models for PB

	
(a) $p_e/\beta > p_b/(1-\alpha)$	**(b)** $p_b/(1+\alpha) > p_e/\beta > p_b/(1-\alpha) - t$ and $(p_b - p_e)/(1+\alpha -$
	
(c) $p_b/(1+\alpha) > p_e/\beta > p_b/(1-\alpha) - t$ and $(p_b - p_e)/(1+\alpha -\beta)$	**(d)** $p_b/(1+\alpha) - t > p_e/\beta > (p_b - t - \alpha)/(1+\alpha)$ and $(p_b - p_e)$



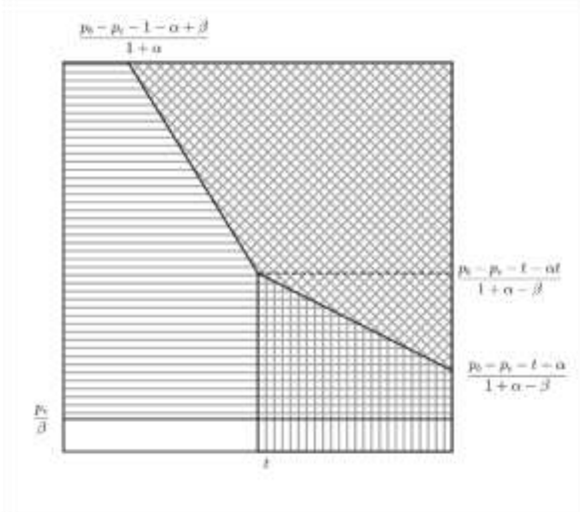
(e)

$p_b/(1+\alpha) - t > p_e/\beta > (p_b - t - \alpha)/(1+\alpha)$ and $(p_b - p_e)/(1+\alpha-\beta) > 1$



(f)

$(p_b - t - \alpha)/(1+\alpha) > p_e/\beta > 0$ and $(p_b - p_e)/(1+\alpha-\beta) <$



(g)

$(p_b - t - \alpha)/(1+\alpha) > p_e/\beta > 0$ and $(p_b - p_e)/(1+\alpha-\beta) > 1$

Legend:
Buy nothing

Buy bundling product

Buy piracy software product

Buy vendor E's service product

Buy vendor E's service product and piracy software product

Notes:

	$p_e/\beta > p_b/(1+\alpha)$	$p_b/(1+\alpha) > p_e/\beta > p_b/(1-\alpha) - t$	$p_b/(1+\alpha) - t > p_e/\beta > (p_b - t - \alpha)/(1+\alpha)$	$(p_b - t - \alpha)/(1+\alpha) > p_e/\beta > 0$
$\frac{p_b - p_e}{1+\alpha-\beta} < 1$	**(a)**	**(b)**	**(d)**	**(f)**
$\frac{p_b - p_e}{1+\alpha-\beta} > 1$		**(c)**	**(e)**	**(g)**